CPG 2-1A4
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 4

WHAT THE PLANNER NEEDS TO KNOW ABOUT ELECTROMAGNETIC PULSE

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

LIST OF CHAPTER TITLES

PREFACE TO CHAPTER 4

This discussion of EMP effects is aimed at the emergency planner and operator rather than the engineer or communications specialist. It is assumed that the reader is familiar with the material in the three preceding chapters. Since equipment damage from the electromagnetic pulse (EMP) is most significant for a detonation outside the earth's atmosphere, other effects of high-altitude bursts (radio blackout and thermal radiation) have been included. Chapter 4 is the only chapter in this Manual that discusses these high-altitude attack effects.

Information is presented in the form of "panels" each consisting of a page of text and an associated sketch, photograph, chart or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 4 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with two introductory panels, followed by five panels on the general nature of the electromagnetic pulse. There follow five panels summarizing the likely effects on various communications and power systems. One panel describes ways to minimize EMP damage to these systems. Finally, two panels discuss the accompanying high-altitude effects of radio blackout and thermal ignitions. A list of suggested additional reading is included in the summary panel.

CONTENTS OF CHAPTER 4

"WHAT THE PLANNER NEEDS TO KNOW ABOUT ELECTROMAGNETIC PULSE"

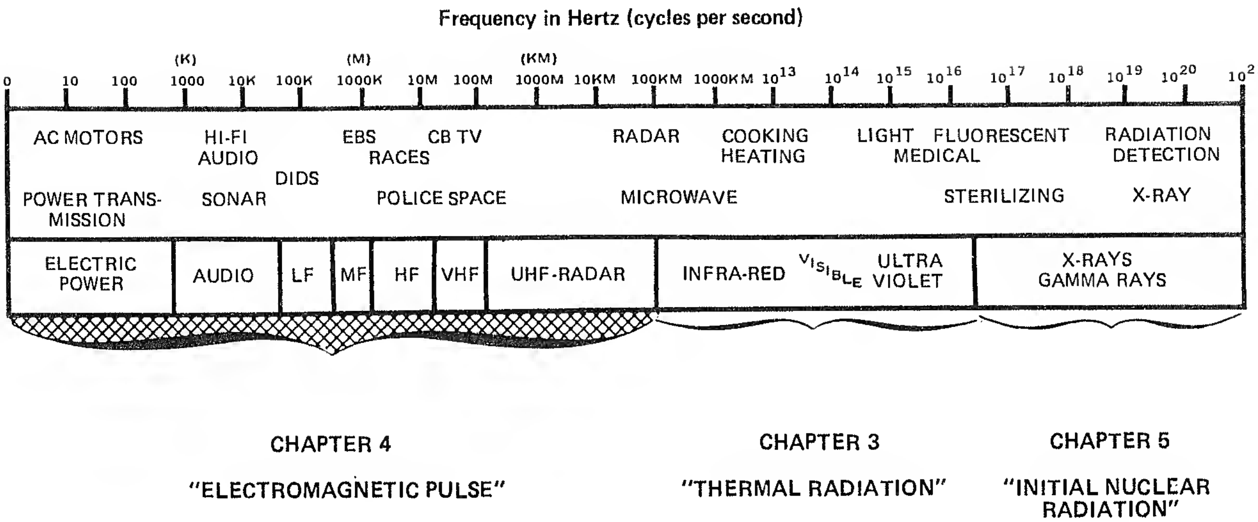
WHAT IS "EMP"?

In Chapter 3 we discussed the capability of the thermal radiation pulse to burn the skin of exposed people and to ignite thin flammable materials within the area damaged by the blast wave. We loosely called this radiated energy "heat radiation" to appeal to the human senses. The radiation itself, of course, is merely a form of electromagnetic radiation, such as is sunlight, which manifests itself by a rise in temperature as it is absorbed in or near the surface of objects it strikes.

A nuclear detonation also emits electromagnetic radiation of longer wavelengths (lower frequency) than the infra-red and visible light of the thermal pulse. Most of this energy is radiated in the frequency bands commonly used for radio and TV communications. For this reason, it could also be called the "radio flash."

It is in the electric power and radio frequencies that the electrical and magnetic aspects of electromagnetic radiation have been prominent. If the reader were an electrical or electronic engineer or a communications expert, it would be appropriate to describe the complexities of the phenomena involved in the EMP from a nuclear explosion. We will not do this partly because we cannot assume the reader is an expert and partly because the planner does not really need to know the technical details to recognize and include the EMP threat in his emergency operating plans.

THE ELECTROMAGNETIC RADIATION SPECTRUM



PANEL 1

WHY WORRY ABOUT EMP?

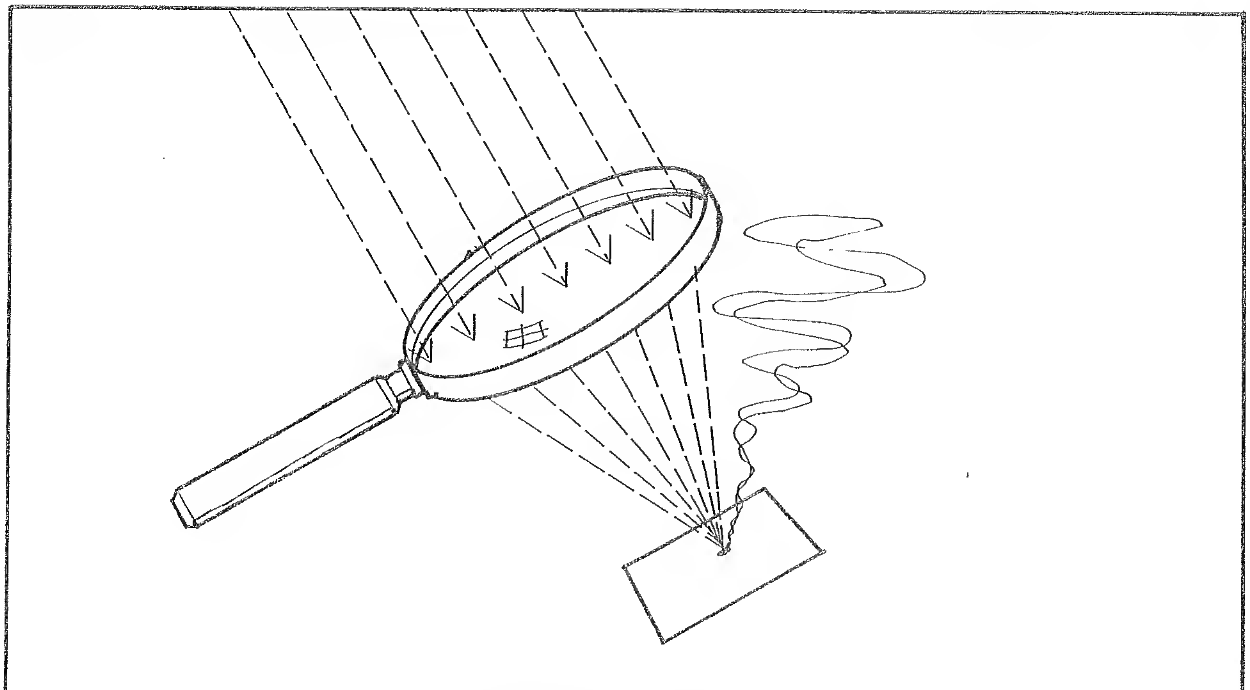
Few people have ever heard of EMP or "radio flash." It might be called the "forgotten" nuclear weapon effect. It was not mentioned in either the 1950 "Effects of Atomic Weapons" or the 1957 "Effects of Nuclear Weapons." EMP was first mentioned in a chapter on radio and radar effects in the 1962 version of the "Effects of Nuclear Weapons" but the description was brief and no hint was given as to its damaging effects.

One reason for this lack of attention has been that the energy contained in the "radio flash" is much smaller than that in the thermal pulse. We saw in Chapter 3 that where the blast overpressure is 5 psi, the thermal energy is about 100 calories per square centimeter. At the same distance from a surface burst, the radio flash energy is equivalent to much less than one calorie per square centimeter.

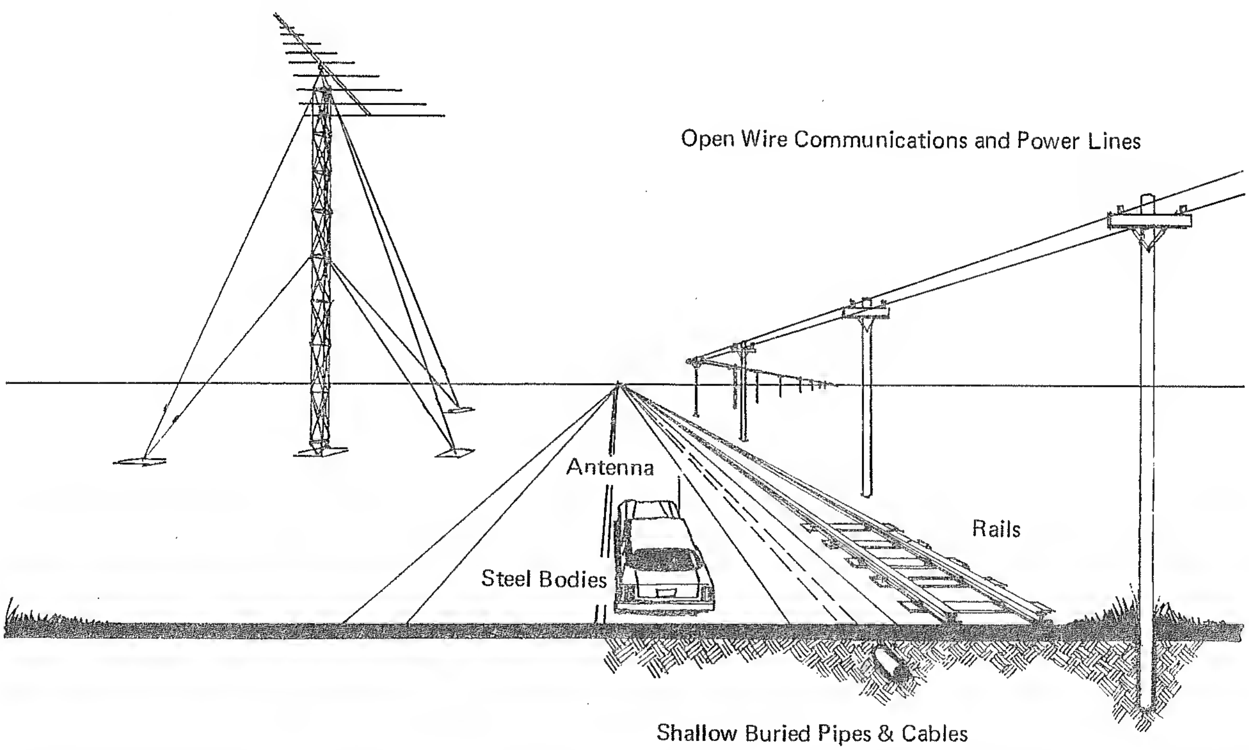
We know that sunlight can be focused by a magnifying glass so as to ignite paper. If magnifying glasses or their equivalent were common in target areas, we would need to be concerned about very low levels of thermal radiation in nuclear attack. Fortunately, this is not the case. But natural energy collectors for radio frequencies are widespread. They magnify the weak "radio flash" somewhat as a magnifying glass does sunlight.

Anyone who has hooked up an old radio to a bedspring knows that almost any metallic object can collect energy from radio waves. Any long wire can pick up the energy in the electromagnetic field and then deliver it in the form of current and voltage pulses to the attached equipment. The larger or longer the conductor, the greater the amount of energy collected. For example, the short antenna of an automobile radio will collect less energy than a large broadcast station transmitting antenna. Typical collectors of EMP energy include long exposed cable runs, piping or conduit, large antennas, metallic guy wires, power and telephone lines, and even shallow-buried pipes and cables, long runs of electrical wiring in buildings, and the like. Sufficient energy can be collected by these means to cause damage to attached electrical and electronic equipment.

PANEL 2



A THERMAL ENERGY COLLECTOR



EMP ENERGY COLLECTORS

PANEL 2

SURFACE BURST EMP

There are two burst conditions of major concern with respect to EMP: (1) the surface or near-surface burst, and (2) the high altitude detonation above the earth's atmosphere. Detonations at altitudes between these two conditions produce much lower intensities of EMP.

For a tiny fraction of a second before the fireball is formed, the X-rays from the exploded nuclear weapon create an oscillation of electrical charges in the air molecules surrounding the explosion. This region, somewhat smaller than the subsequent fireball, is called the "source region." A brief pulse of electromagnetic energy is radiated outward as shown in the upper illustration.

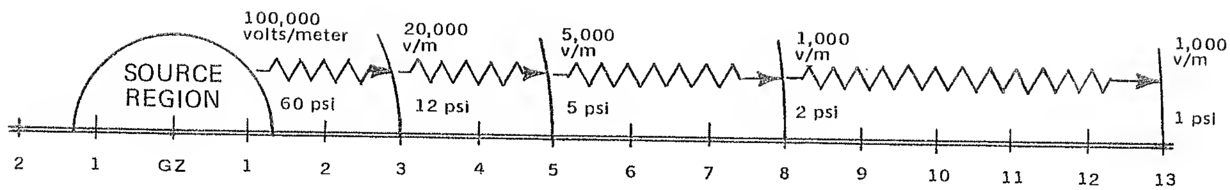
The strength of a radio wave is measured in terms of the voltage stress produced in space by the electric field of the wave, usually expressed in microvolts (millionths of a volt) per meter. This measure is also the voltage that the magnetic field of the wave induces in a conductor 1 meter long when sweeping across this conductor with the speed of light. (A meter is a little over 39 inches or about 10 percent longer than a yard.)

But the field strength in the EMP pulse is not measured in microvolts. Rather, thousands of volts or "kilovolts" per meter is a more appropriate measure. The table shows a comparison of the maximum EMP field strength with more common sources, in every case close to the "source region," whether it be detonation, transmitter, or power line.

Ordinary radio receivers are designed to sense very low levels of electromagnetic energy. Under some circumstances, signal strengths as low as 0.1 microvolt per meter are usable. Occasionally, signal strengths exceeding 1000 microvolts (1 millivolt) per meter are required to assure satisfactory radio reception. In most cases, the weakest useful signal strength lies between these extremes.

The thousands of volts per meter in the EMP pulse is in a different "ballpark" compared to signal strengths used in communications.

EMP FROM A 5–MT SURFACE BURST



DISTANCE FROM GZ, MILES

COMPARISON OF ELECTROMAGNETIC FIELDS

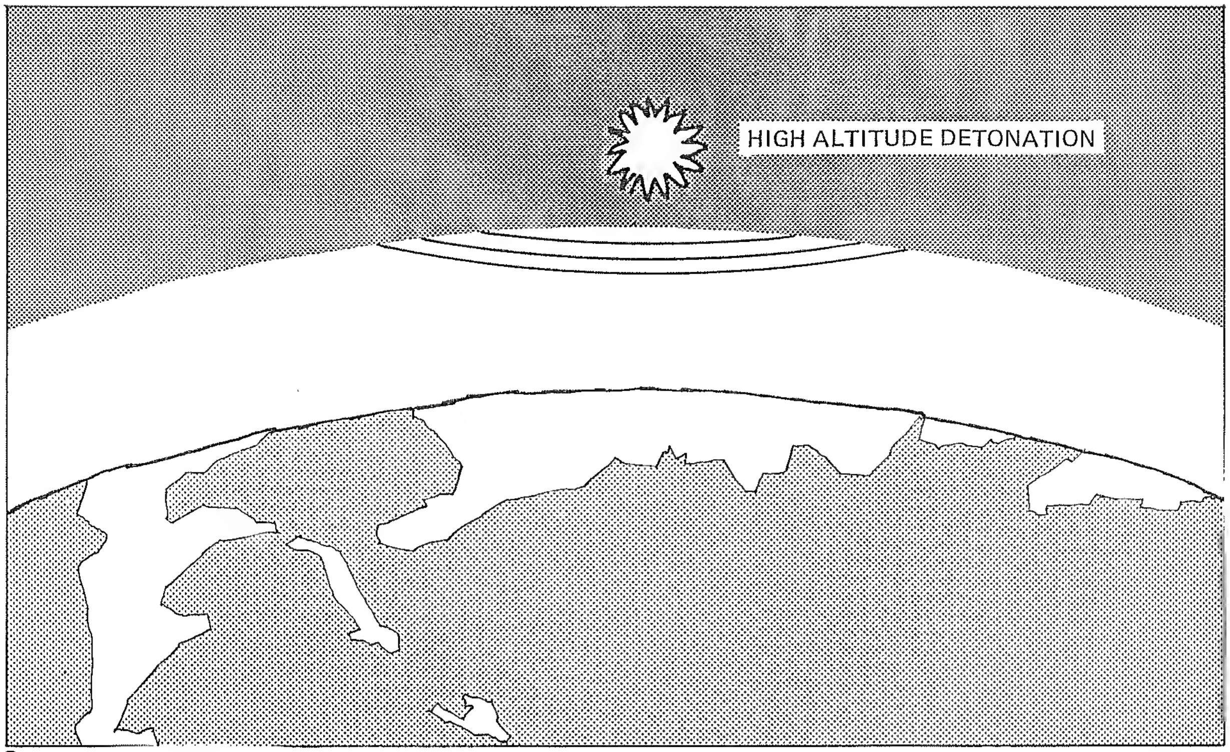
SOURCE	INTENSITY (volts per meter)
EMP	UP TO 100,000
RADAR	200
RADIO COMMUNICATION	10
METROPOLITON "NOISE"	0.1

Source: Defense Nuclear Agency

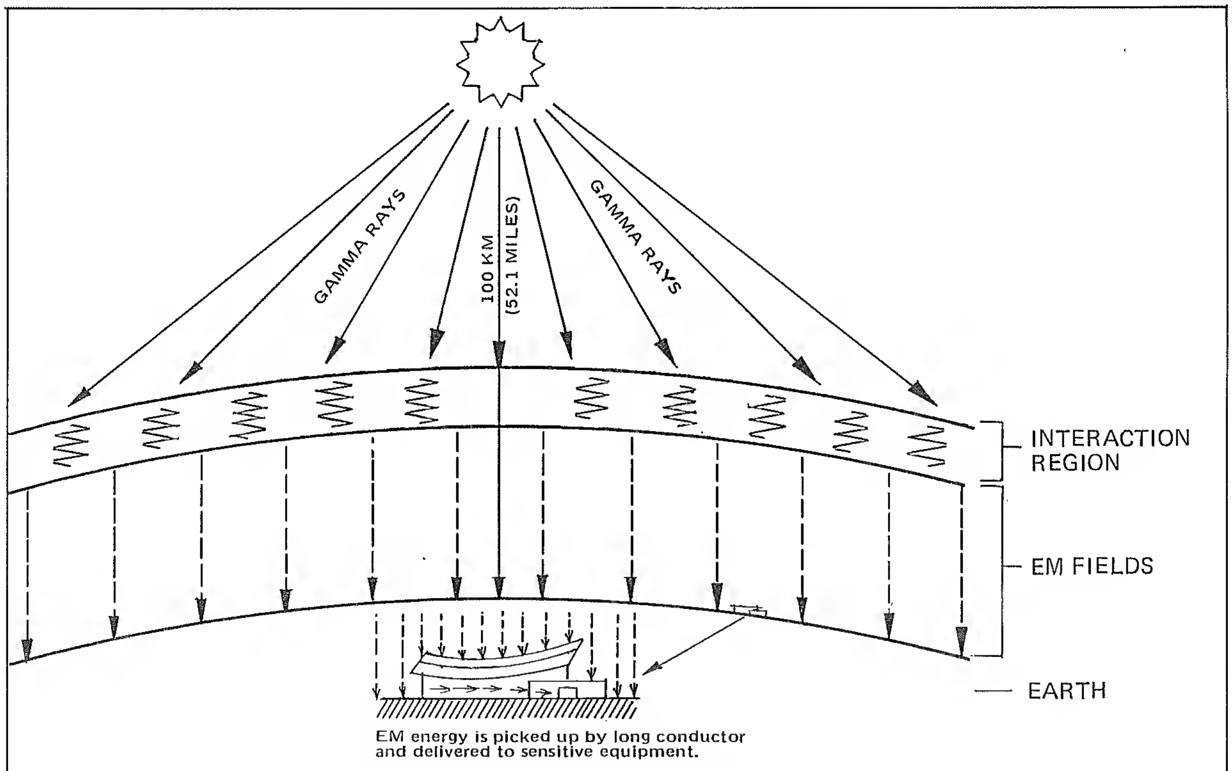
HIGH-ALTITUDE BURST EMP

If a nuclear weapon is detonated high above the earth's atmosphere (an exoatmospheric burst), the X-rays and gamma rays emitted downward from the explosion will be absorbed in a big "pancake" layer of the atmosphere between 12½ and 25 miles above the earth's surface, as shown in the upper view.

The gamma energy is converted into lower-frequency electromagnetic energy in this interaction region and propagated downward to the earth's surface as a very brief but powerful electromagnetic pulse. The strength of this pulse on the ground is in the order of tens of thousands of volts per meter, much the same as the field strength in the moderate damage area of a surface burst. However, very large areas, otherwise undamaged, can be affected by the high altitude detonation, as the lateral extent of the "interaction region" is generally limited only by the curvature of the earth.



Source: Defense Nuclear Agency



EMP ENERGY FROM HIGH ALTITUDE BURST.

PANEL 4 From Survive, November-December 1969.

EMP COVERAGE

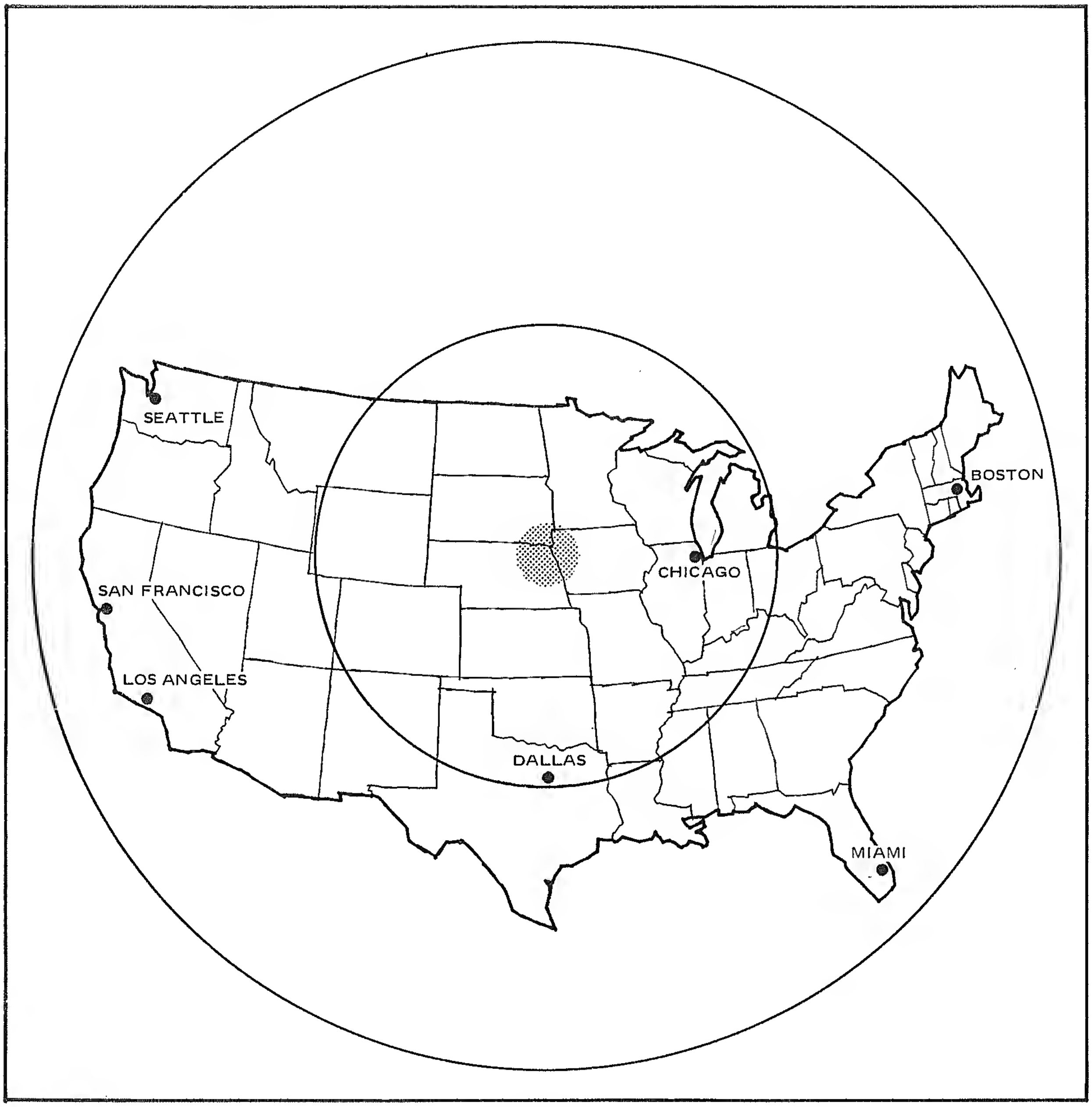
In the case of an exoatmospheric burst, blast damage does not occur and other effects are minor except for the EMP. The source region at 12½ to 25 miles above the earth's surface can be quite large, perhaps a thousand miles in diameter. As a consequence, the radiated fields from this source region can cover a substantial fraction of the earth's surface.

A typical high-altitude burst over Omaha, Nebraska, is shown here. Within the circle passing through Dallas, Texas, ground-level fields of a few tens of thousands of volts per meter would be created. The outer circle shows that a few kilovolts per meter would occur everywhere within the contiguous 48 states.

That these pulses can cause damage to electrical and electronic equipment is not a matter of scientific theory. The failure of approximately 30 strings of street lights on Oahu at the time of the Starfish detonation about 750 miles away over Johnson Island was the most publicized effect during the weapons test series Operation FISHBOWL in 1962.

High-altitude bursts are no longer unlikely. The deployment of those ballistic missile defenses permitted by the recent treaty with the Soviet Union would include the use of megaton-yield warheads to intercept incoming weapons outside the atmosphere. Even if this were not in prospect, the effectiveness of EMP in interrupting communications would make it probable that some of the thousands of warheads discussed in Chapter 1 would be used for this purpose.

An implication for operational planning is that a potential EMP threat must be anticipated in every locality during the first minutes and perhaps hours after a nuclear attack is initiated.



EMP GROUND COVERAGE OF HIGH ALTITUDE BURSTS

Source: Defense Nuclear Agency

PANEL 5

DAMAGE FROM EMP

Two kinds of damage can be caused by the EMP pulse:

(1) Functional damage, requiring replacement of a component or piece of equipment. Examples would be the burnout of a radio receiver "front end" or blowing of a fuse.

(2) Operational upset, a temporary interruption or impairment of electrical equipment such as opening of circuit breakers or erasure of a portion of the memory of a computer.

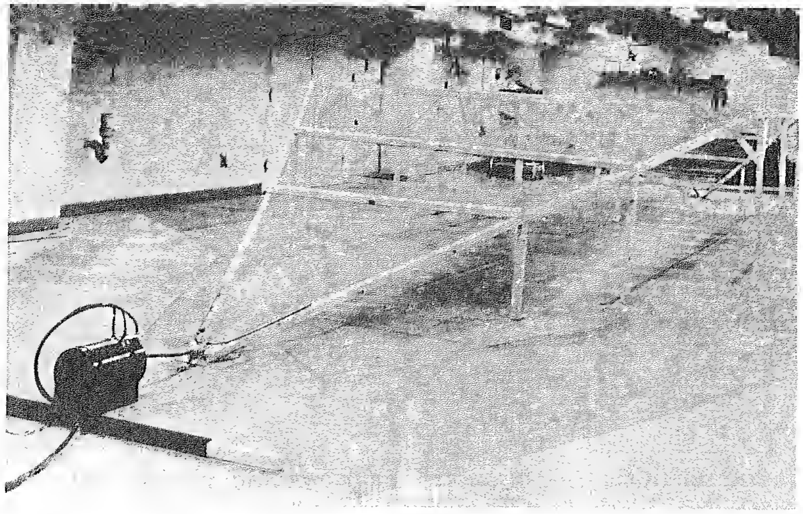
Functional damage is of greatest significance to civil defense operations since temporary interruptions of communications or power are not likely to be crucial.

The response of an electronic or electrical system to EMP is often highly dependent on obscure details. They may include defects in welds, minute cracks and seams, the quality of soldered joints, or the type of grounding system. Because these obscure details often determine the actual vulnerability, experimental facilities have been relied upon since the atmospheric test ban to simulate the EMP from a nuclear weapon. One such experimental facility, used to test pieces of equipment, is shown in the upper photograph. Equipment placed within the enclosure is subjected to "threat-level" EMP pulses, usually repeatedly, to determine whether either functional damage or operational upset is likely to occur.

Experiments have shown that civil defense radiation detection equipment is not susceptible to direct damage nor are hand-held Citizens Band walkie-talkies or FM radio receivers. Generally, the relative vulnerability of components shown in the lower chart has been determined, with transistorized equipment most susceptible.

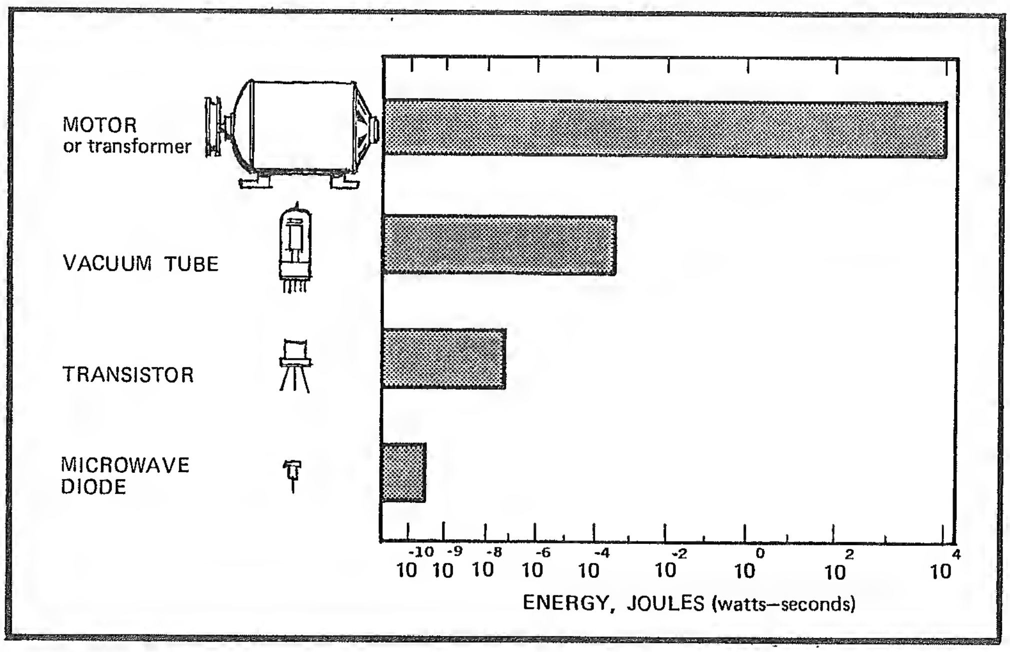
It has been found that communications equipment employing bipolar transistors with self-contained batteries and loop antennas are not susceptible to direct EMP damage. Similar equipment with stick antennas up to 40 inches long can be operated safely. Equipment using field-effect transistors may suffer damage if connected to an antenna exceeding 30 inches in length.

The general implication of these results is that mobile communications equipment is relatively survivable while radio base stations are vulnerable unless protected against EMP.



ONE TYPE OF EMP SIMULATOR

IITRI Laboratory photograph.



SENSITIVITY OF VARIOUS COMPONENTS

NOTE: 300 feet of wire can absorb about 1/10 to 40 joules of energy depending on orientation and proximity to other conductors.

Source: Defense Nuclear Agency

PANEL 6

EMP AND LIGHTNING

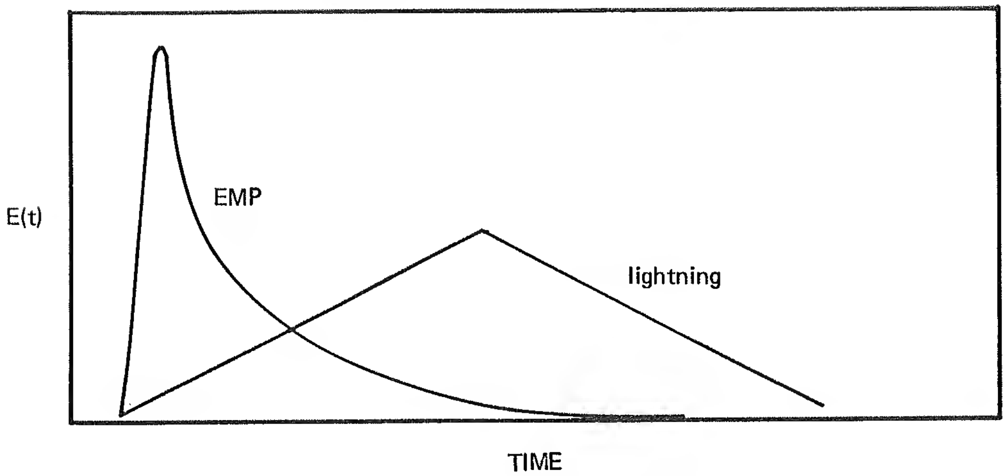
Engineers and scientists have discussed the protection of radio and electrical equipment from EMP effects by comparing this problem with that of protection against lightning. Lightning is the only naturally occurring phenomenon that has electrical currents, voltages, and fields associated with it that are in any way comparable to the electromagnetic effect of a nuclear explosion. Everyone has heard the electromagnetic "static" produced in radio reception by distant lightning strokes. Most people are aware that large antennas and other tall structures are protected by "lightning arrestors" to prevent damage to sensitive equipment.

The upper sketch shows that EMP occurs much more rapidly than does a lightning stroke. Thus, devices, such as spark gaps, that are suitable for lightning protection may permit large EMP-induced overvoltages to pass before they operate.

The lower sketch shows that EMP is a broadband pulse with frequencies ranging from almost zero to more than one hundred megahertz. It therefore spans all of the communications frequencies. The electromagnetic waves associated with lightning are confined to the lower frequencies. Thus, filtering out the EMP frequencies is more difficult than is the case with lightning.

PANEL 7

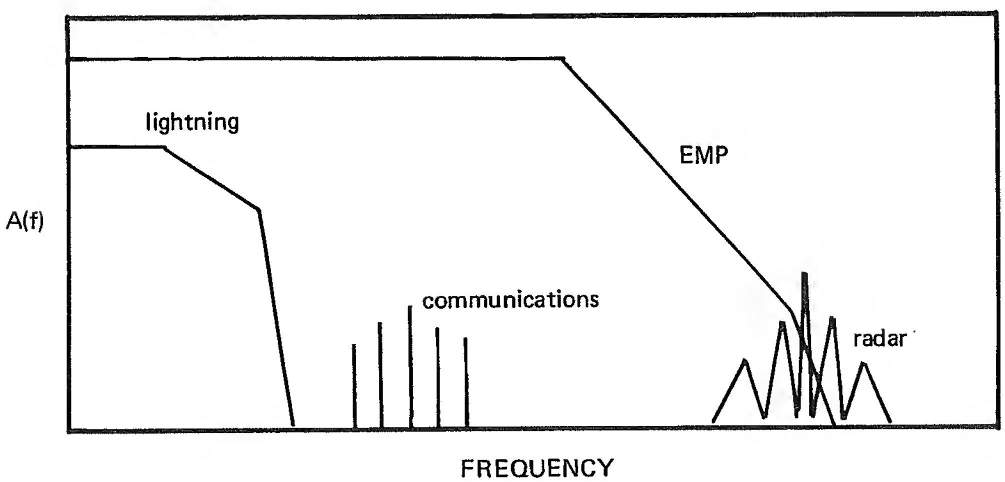
TIME HISTORY
COMPARISON WITH LIGHTNING



NOTE: Rapid rise of EMP pulse

Source: Defense Nuclear Agency

SPECTRUM COMPARISON



NOTE: Broad frequency range of EMP

Source: Defense Nuclear Agency

PANEL 7

VULNERABILITY OF BROADCAST RADIO

EMP poses a potential threat to AM, FM, and TV broadcast transmitters. There are three areas of concern regarding EMP damage to radio station operation: (1) pulse energies collected by large broadcast antennas; (2) conducted pulses from power lines and other long external conductors; and (3) directly induced transient currents in transmitter circuits.

Although the energy collected by a large antenna may be less than from an average direct lightning stroke, the limited protective action of the usual spark gap may place a strain on transmitter, antenna insulators, transmission lines, and matching network components exceeding that of lightning. Since lightning frequently damages high-voltage capacitors, it may be concluded that EMP would cause capacitor damage and perhaps damage to other components as well.

Damage from commercial power connections is also possible since about one-quarter of the voltage collected by the power lines will pass the nearby distribution transformers. And damage from power lines could be more serious than from antenna coupling as the damage could be harder to diagnose and rectify. A standby electric generator would solve this problem, provided the station can be disconnected from commercial power before the first detonation. Because this must be done manually, station personnel should make provisions to react promptly to attack warning.

Broadcast station wiring and circuits can act like loop and wire antennas, collecting radiated energy. Transistors are especially susceptible to low-level energy pulses induced in connected circuits. Vacuum-tube transmitters are much less vulnerable.

There are many known ways to protect broadcast stations from possible EMP damage. Technical training is required to understand these protective measures. The planner should assure that local broadcast station operators have access to the DCPA publication TR-61-C, **EMP Protection for AM Radio Broadcast Stations**. This document contains much detail on low-cost corrective actions that can be taken. (See Panel 16.)

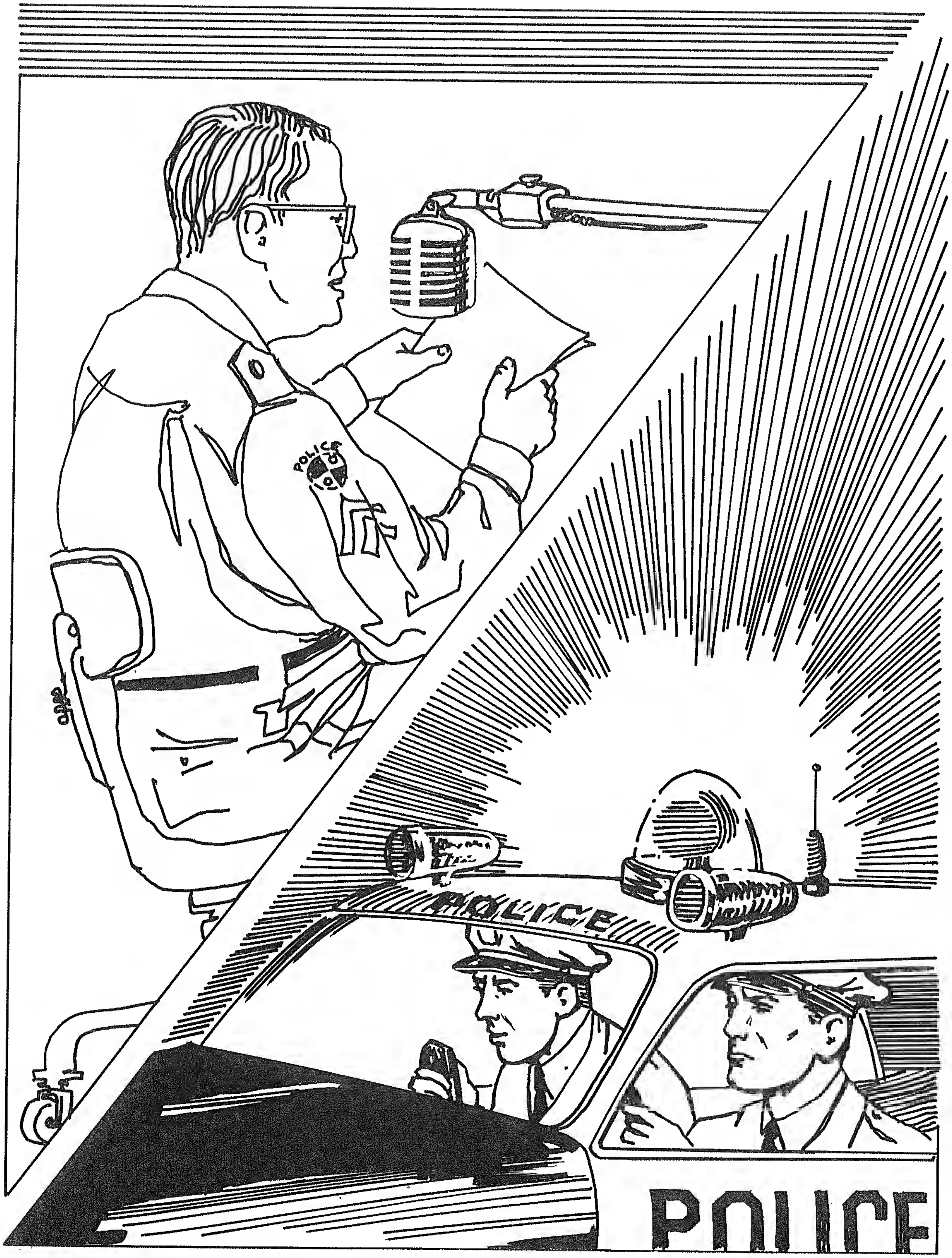
AM BROADCAST STATION ANTENNA AND TRANSMITTER BUILDING

PANEL 8

VULNERABILITY OF PUBLIC SAFETY RADIO

Police, fire, public works, and other local government radio nets usually perform a crucial role in disaster operations. To these systems can be added emergency amateur radio organizations, such as RACES. The base stations (and relay stations) in these networks have the same general vulnerability to EMP as do commercial broadcast stations. Even at high frequencies where antennas are short, long cables are often used to connect the antenna to the transmitter. Furthermore, many base stations cannot operate in the absence of commercial power. Unless these facilities are equipped with standby electric power and EMP protective devices, they are likely to go off the air in a nuclear emergency.

Mobile units in these systems have battery power supplies and relatively short antennas. They are most likely to remain operable. The implication for emergency planners is that arrangements to permit mobile-to-mobile communications will be important as an alternative in the event of loss of a base station.

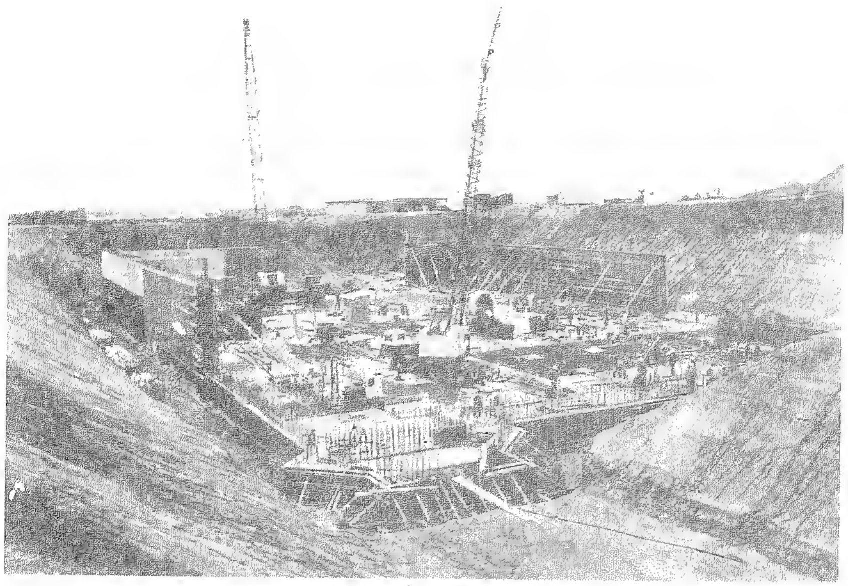


PANEL 9

VULNERABILITY OF TELEPHONE SYSTEMS

Telephones are another important communication resource for emergency operations. In addition to the public telephone system, telephone lines are often used in public safety radio nets to connect dispatchers to transmitters and to interconnect transmitters. The American Telephone and Telegraph Company has taken strong measures to render transcontinental and other critical land lines relatively invulnerable to nuclear attack, including EMP effects. The vulnerability of local telephone exchanges is less well defined but certain characteristics are favorable. Local exchanges do not depend on commercial power. Increasingly, lines are being placed belowground rather than on poles. Nonetheless, some components of conventional telephone plants are very sensitive to the effects of EMP. Despite the rugged and conservative design and construction used in telephone systems, these are not sufficient to give high confidence that telephone service will operate reliably immediately after exposure to EMP.

Despite these problems, the use of the local telephone system should hold a key place in local emergency planning. Local radio nets are used mainly to communicate with mobile units in the field. During the major part of the nuclear attack period, these units should be parked as discussed in Chapter 2, with the personnel taking refuge in the best available shelter. Moreover, the telephone system is the one system that cannot be disconnected in the way a radio transmitter can. Therefore, it would be prudent to plan for maximum use of telephone service between temporarily immobilized field units and dispatchers so long as service continues, reserving the radio service until the main threat of EMP damage is past.



PROTECTED FACILITY FOR AT&T LONG LINES DEPARTMENT UNDER CONSTRUCTION

Bell Laboratory Record, January 1969.

PANEL 10

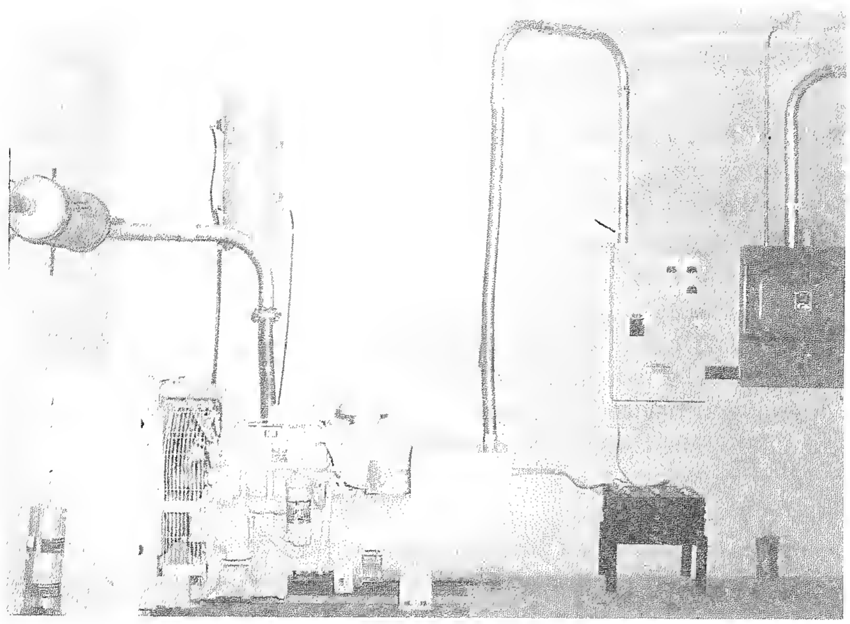
VULNERABILITY OF ELECTRIC POWER

Power lines exposed to EMP will have induced in them currents and associated voltage surges in much the same way that antennas collect radio signals. For power systems, this means that a high altitude detonation will induce surges on all the myriad of power conductors, control and communication cables, interconnecting wires, and other conductors virtually simultaneously throughout the entire system. Probably the largest surges will occur on overhead power lines because they are located well above the earth and are essentially unshielded. Moreover, overhead "ground wires" that are used to shunt lightning strokes have little effect on the magnitude of EMP-induced surges. Surge voltages on overhead power lines may be sufficiently large to cause arcing in substations and at branches or changes in direction along the lines. Insulators can be damaged and circuit breakers locked out.

System "instability" is a probable result of these outages. Since the major blackout of the Northeastern part of the U.S. in 1965, most people are aware of the catastrophic and widespread effects of system instability. The cumulative weight of EMP effects thus makes likely widespread power failure on a national scale at the very beginning of a nuclear attack.

Recall that in Chapter 2, Panel 30, we described the effects of blast damage on the electric power system. Blast damage would be extensive above 5 psi. In the moderate damage region, early restoration of power seemed likely and, beyond the reach of 2 psi, the distribution system would be essentially intact. Even here, however, the availability of electric power would depend on the amount of EMP damage and measures taken to repair the damage that occurred.

The implication for emergency planning is that no reliance should be placed on the presumed availability of electric power during and immediately following a nuclear attack.



TYPICAL VIEW OF A STANDBY EMERGENCY GENERATING PLANT FOR AN EOC OR EBS STATION

VULNERABILITY OF EMERGENCY OPERATING CENTERS

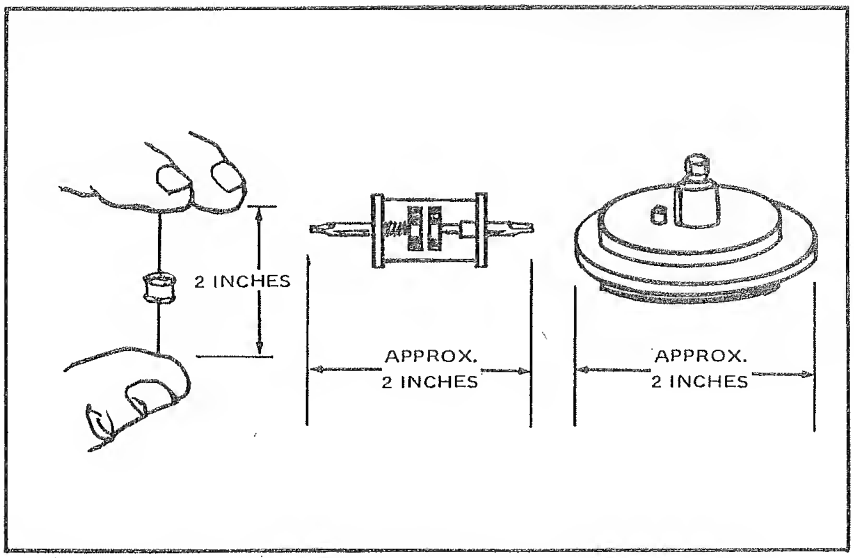
The local EOC represents a key nerve center for emergency operations. As such, it must be in a position to communicate with others during and after a nuclear attack. Since EMP from high-altitude detonations can cripple communications anywhere in the country, every locality must concern itself with protection of its EOC from EMP effects.

An obvious first step is to provide standby emergency power and a means for disconnecting from the commercial power that will effectively prevent line surges from passing through the transfer switch. Operating procedures should provide for switching to emergency power at the maximum readiness condition or at Attack Warning rather than waiting until weapons detonate or power is lost.

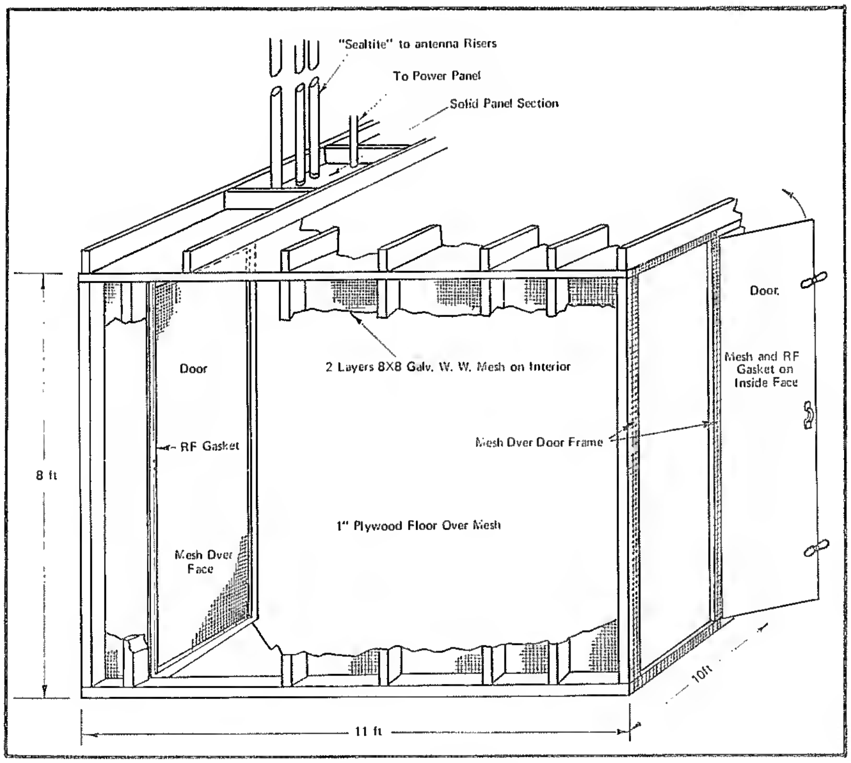
The next step is to protect communications equipment against voltage surges from other incoming lines, such as telephone and antenna lead-in cables. Devices for this purpose, such as gas-gap shunting devices that react very rapidly, are now becoming available commerically at low cost. The upper view shows typical components of this sort that can be obtained for a dollar or two.

Finally, the communications equipment itself should be placed in a shielded enclosure. A solid metal lining for the communications room is best, but a galvanized steel-wire mesh enclosure, properly grounded, is also satisfactory. One such enclosure that can be locally constructed is shown in the lower view.

Of course, it is simpler, cheaper, and more effective to incorporate EMP protection in the design of a new EOC than it is to retrofit an existing facility. When planning a new EOC, this should be done. The Engineering Support Group at the nearest DCPA Regional Operating Center is available for advice in these matters. Additionally, the DCPA TR-61 series of technical guidance reports will be found useful. (See Panel 16.)



GAS-GAP SURGE ARRESTOR (also called spark-gaps)



SHIELDED BOX

PANEL 12

OPERATIONAL EMP DEFENSES

Whether or not physical EMP hardening has been accomplished in local EOC and communications facilities, there are a number of low-cost operational actions that should be incorporated into emergency operating plans to deal with the possibility of EMP damage. These actions can help minimize the possibility of catastrophic communications failure. Some of the actions shown here can be undertaken readily; others may require some modifications in equipment before they can be incorporated in plans and SOPs.

Maintain an extra supply of spare parts and standby components so that EMP damage, should it occur, can be rectified as quickly as possible. Elements most likely to be affected are identified in DCPA publications or can be identified by assistance from the DCPA Region. If vulnerable elements are located in unprotected or unmanned areas, repair actions should be planned as essential emergency actions.

The need for specific plans to shift to emergency power as early as possible and desirability of relying on telephone reporting during the early shelter phase have been mentioned before.

If telephone service fails or if there is no alternative to continued use of certain radio nets, the use of existing facilities in a coordinated way should be investigated and planned for. There are a variety of ways in which coordinated communications can be achieved. If the community or area has set aside a common emergency frequency, as many base stations as possible should be equipped to transmit on this frequency in addition to normal frequencies. Then, plan to use only one base station at a time for essential communications to all services. Alternatively, essential field units can be equipped to monitor and/or transmit on several nets, such as police, fire, and public works. Again, only one base station would be used at a time during the threat period. Those not required should be disconnected from antennas, power lines, and other long conductors to avoid EMP damage.

Also, plan to back up the normal transmitter capability by mobile-to-mobile communications. For systems that use one frequency for transmitting from base stations and another for mobile response, this backup capability would require mobile communications vans or the equipping of a limited number of mobile units to transmit on both frequencies. Such backup arrangements have been found useful in hurricanes, tornadoes, and other natural disasters.

Finally, emergency operations plans should be designed so that they are not completely dependent on communications with the EOC or normal dispatching procedures. The ways to do this are described in Chapter 9.

PANEL 13

SEVEN ANTI-EMP ACTIONS

1. Maintain a supply of spare parts.

2. Shift to emergency power at the earliest possible time.

3. Rely on telephone contact during threat period so long as it remains operational.

4. If radio communication is essential during threat period, use only one system at a time. Disconnect all other systems from antennas, cables, and power (do not use low-voltage switches but pull the plug).

5. Disconnect radio base stations when not in use from antennas and power line.

6. Plan for mobile-to-mobile backup communications.

7. Design emergency operating plans so that operations will "degrade gracefully" if communications are lost.

RADIO BLACKOUT

Since this Chapter is the only one in which we will consider directly the effects of high-altitude nuclear detonations, the planner should be aware of some effects other than EMP that might affect emergency operations. One of these "lesser effects" is radio "blackout."

Radio blackout occurs when the debris and radiations from a nuclear weapon cause major alterations in the electrical properties of the high atmosphere upon which some radio communications depend. This region, called the "ionosphere," extends from about 40 to 300 miles above the earth's surface. High-altitude detonations produce a large amount of electrical "fog" in the ionosphere, although surface and near-surface bursts in the megaton yield range can also have some effect.

As shown here, long-distance communications in the high-frequency (HF) band can be interrupted for several hours since they depend on the bending of radio waves back toward the earth for distant communication. Short-range communications within a city or county are unlikely to be affected by radio blackout. The current trend toward use of very-high-frequency (VHF) and ultra-high-frequency (UHF) bands for public safety and amateur broadcasts decreases the likelihood of blackout of these communications.

The "20-meter" and "40-meter" bands are still popular for long-distance amateur communications, however. Since radio blackout can be confused with EMP damage to equipment, the planner should take account of its existence. Radio blackout will not cause damage to equipment, merely interfering temporarily with receipt of radio transmissions. This is unlikely to be of serious consequence to emergency operations.

SUSCEPTIBILITY TO RADIO BLACKOUT

Radio Band	Frequencies	Example	Effects
LF	30 - 300 KHZ	DIDS	Least affected
MF	300 - 3000 KHZ	EBS	Some distant interference
HF	3000 - 30,000 KHZ	RACES	Many hours
VHF	30,000 KHZ - 300 MHZ	High-band Public Safety	Few seconds to minutes
UHF	300 - 3000 MHZ	TV, Latest Public Safety	Little effect
SHF	3 - 30 GHZ	Microwave and Satellite	Virtually no effect

HIGH-ALTITUDE THERMAL EFFECTS

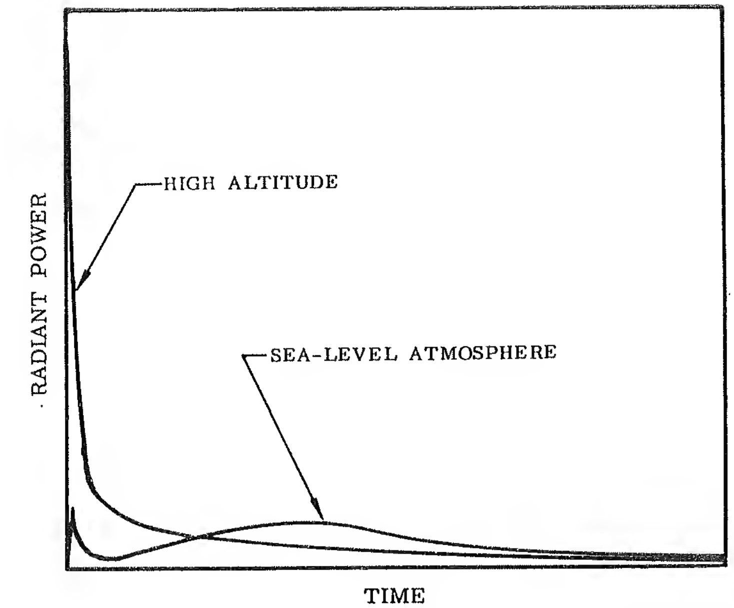
Below a height of about 20 miles above the earth's surface, the thermal radiation pulse accompanying a nuclear detonation has the characteristics described in Chapter 3 and corresponding effects. Above 20 miles, however, the rarefied atmosphere in which the burst occurs results in most of the thermal radiation being emitted in a brief pulse of about a second's duration. In other words, the "heat flash" from a 25-MT detonation at high altitude could be similar to that which occurred from kiloton-yield weapons at Hiroshima and the Nevada Proving Grounds.

The importance of this behavior lies in the fact brought out in Chapter 3 that it is the rate of energy delivery that determines whether ignitions will occur. As a consequence, common kindling fuels could ignite at about half the total energy delivery (in calories per square centimeter) described in Chapter 3. Of course, the detonation itself occurs at a great distance from the earth's surface and this compensates a great deal for the added susceptibility of kindling fuels.

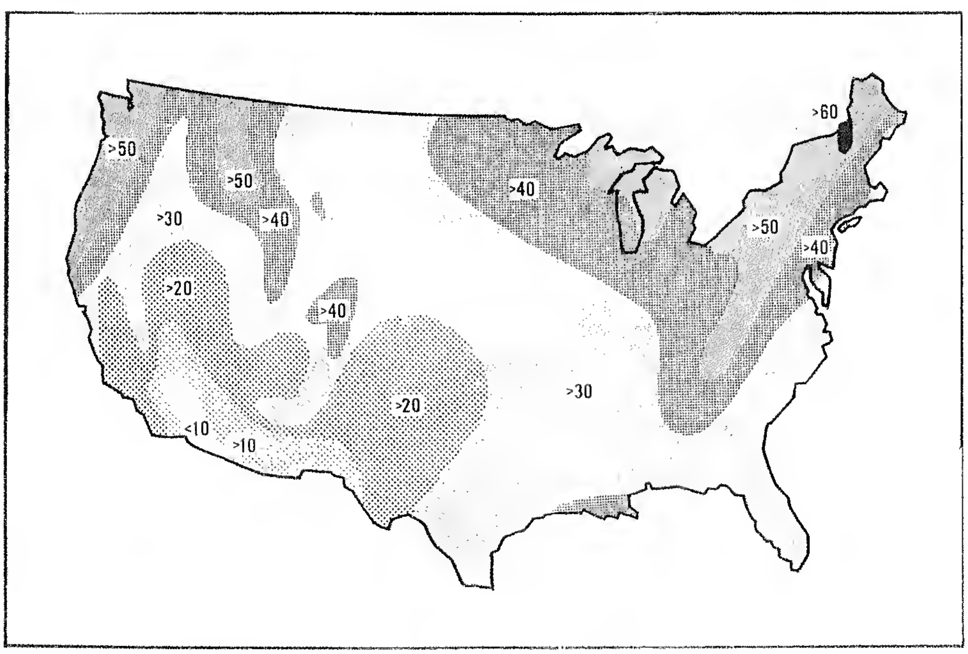
If a 25-MT weapon were detonated at a height of 60 miles, which is a "good" altitude for causing EMP damage, the thermal energy reaching the ground on a clear day would be about 4 calories per square centimeter directly under the explosion. This would be just enough to cause ignition of exposed ignitables of the most sensitive class. But the high-altitude burst could not "see" into rooms within buildings except at great distances where the thermal energy would be much reduced. If the weapon were detonated at a significantly lower altitude, the EMP effectiveness would be less, the thermal ignition effectiveness greater.

A blast wave would not result from a high-altitude burst to suppress ignitions but neither would windows and screens be blown out. No debris would block firefighting activities and men and equipment would be fully operational. When the facts are added that clouds prevail over a substantial portion of the country nearly every day and it is cloudy in most localities a substantial part of each year, the conclusion has been reached that the use of high-altitude detonations to cause ignitions is a most unlikely tactic.

Nonetheless, weapons might be detonated at high altitudes to cause EMP damage or as a result of missile defense measures. The implication for emergency planning is that possible ignitions should be expected, searched out, and suppressed if found, no matter how remote a nuclear detonation appears to be.



COMPARISON OF RATES OF THERMAL ENERGY RELEASE FOR MEGATION WEAPONS



PERCENTAGE OF ANNUAL "OPAQUE" CLOUDINESS

PANEL 15

SUMMARY

One final point should be made about EMP effects. We do not have to concern ourselves about the effects upon people as we did in Chapters 2 and 3. Without considerable focusing, the EMP energy is totally harmless to living things. Standing in the open, one would literally not feel a thing with respect to the strongest EMP pulse. However, the energy collected in a long wire might cause electrocution or a burn, if a person were touching it at the time. Such conditions are not generally expected.

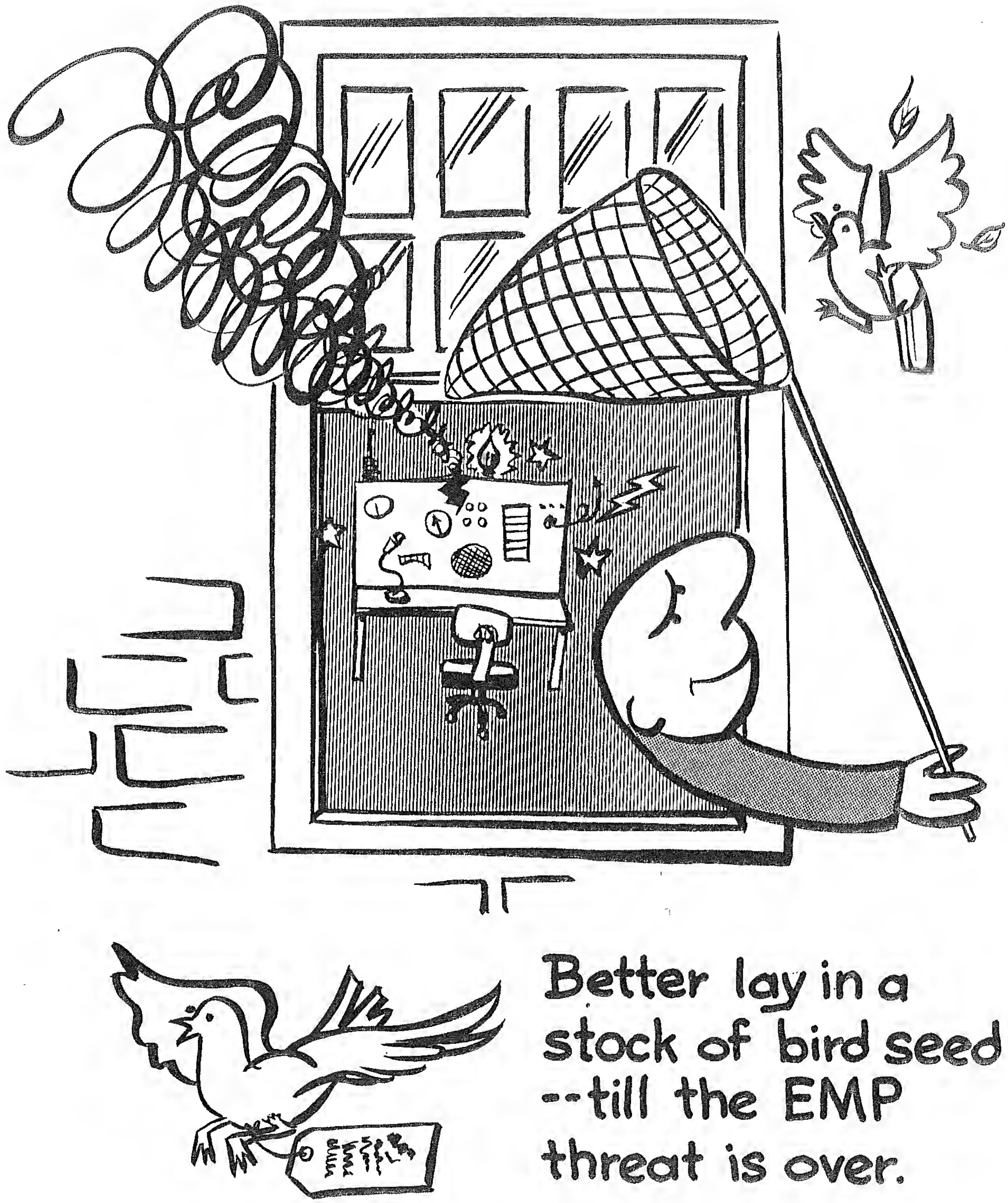
With respect to the protection of communications and electrical equipment, recent research results have been incorporated into the following publications:

EMP Threat and Protective Measures, DCPA TR-61, August 1970.

EMP Protection for Emergency Operating Centers, DCPA TR-61A, May 1971.

EMP Protective Systems, DCPA TR-61B, revised July 1972.

EMP Protection for AM Radio Broadcast Stations, DCPA TR-61C, May 1972.



Courtesy of Don Clark, U.S. Naval Civil Engineering Laboratory.

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